

Amendment Under 37 C.F.R. § 1.111
U.S. Serial No. 09/881,782

REMARKS

Entry of the foregoing, re-examination and reconsideration of the application, as amended, pursuant to and consistent with 37 C.F.R. § 1.111 and in light of the remarks which follow, is respectfully requested.

As correctly noted in the Office Action Summary, claims 1-22 are pending in the application. Of these, claims 8-10 and 18 stand withdrawn from consideration, and the balance of the claims stand rejected.

By the above amendments, claims 1, 11 and 19 have been revised to point out that the whole pad electrode utilized in wire bonding is on the center of the upper surface of the window layer. Moreover, these claims have been amended to recite that the second conduction-type surface ohmic electrodes are not disposed below the pad electrode. Support may be found, at least at page 13, line 8 et seq. and Figs. 3-4. Claim 21 has been revised to recite that the buffer layer is composed of an amorphous body in the as-grown state. Support may be found at page 9, lines 25-28. In addition, claims 2, 3, 5, 6, 12, 13, 15, 16 and 18 have been revised in response to the 35 U.S.C. § 112, second paragraph, rejection and is further discussed below. Claim 22 has been canceled.

At the outset, the undersigned notes the Examiner's remarks with respect to the alleged deficiencies in the Information Disclosure Statement.

The co-pending application listed on the Information Disclosure statement has been identified by its application number, inventor and filing date. This information was provided in a paper separate from the specification of the application, as required by MPEP §609.

Additionally, a complete copy of Application No. 09/691,057 was submitted together with the

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Information Disclosure Statement. Thus, the Information Disclosure Statement is in full compliance with MPEP §609.

In response to the objection to the drawings, Applicant submits herewith Corrected Formal Drawings for Figs. 1 and 2 labeled "PRIOR ART". This drawing correction was approved in the Office Action dated July 25, 2002.

Claims 2, 3, 5, 6, 8, 12, 13, 15, 16 and 18 stand rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for not clearly referring to all of the "plurality of electrodes" or just one of the "plurality of electrodes." This rejection has been obviated by the above amendments where claims 2, 3, 5, 6, 8, 12, 13, 15, 16 and 18 have been revised to more clearly recite a "plurality of electrodes." Therefore, the claims clearly refer to a plurality of second conduction-type surface ohmic electrodes. Accordingly, the meets and bounds of the claims are readily ascertainable. Withdrawal of this rejection is in order and it is respectfully requested.

Claims 1-3, 6, 7 and 21 stand rejected under 35 U.S.C. § 103(a) as being obvious over Ming-Jiunn et al (U.S. Patent No. 6,078,064) in view of Ohba et al (U.S. Patent No. 5,076,860) and Okazaki et al (U.S. Patent No. 5,977,566). The claims, as amended, cannot be rejected on this basis.

The present invention relates to a group-III nitride semiconductor light-emitting diode (LED) having a configuration of ohmic electrodes suitable for diffusing a driving current of a device over a wide range of a light-emitting region.

In accordance with one aspect of the invention, as set forth in amended claim 1, a group-III nitride semiconductor light-emitting diode is provided. The diode includes at least a first

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conduction-type single crystal substrate provided with a first conduction-type back-surface ohmic electrode on a back surface thereof. A buffer layer including a boron phosphide (BP)-based material is disposed on a front surface of the single crystal substrate, a gallium nitride (GaN)-based group-III nitride crystal layer having a light-emitting part of hetero-junction structure is disposed on the buffer layer, and a window layer including an electrically conducting transparent oxide crystal layer is disposed on the group-III nitride crystal layer. At least a second conduction-type surface ohmic electrode conductive with the window layer is disposed between the surface of the group-III nitride crystal layer and the window layer and comes into contact with the surface of the group-III nitride crystal layer. The whole of a pad electrode for wide bonding is on the center of the upper surface of the window layer, and the second conduction-type surface ohmic electrode is composed of a plurality of electrodes which do not exist below the pad electrode.

Ming-Jiunn et al relates to a light emitting diode, and in particular and indium gallium nitride light emitting diode. Ming-Jiunn et al was cited as disclosing an electrode for a light-emitting diode including p-electrode 42 disposed between transparent window layer 11B and clad layer 13, and further including pad electrode 10 disposed on the center of the upper surface of the window layer. Official Action at page 4.

Ming-Jiunn et al does not disclose or fairly suggest each feature of the claimed invention. For example, Ming-Jiunn et al does not disclose a semiconductor light-emitting diode where the second conduction-type surface ohmic electrode does not exist below the pad electrode. In contrast, the ohmic electrodes in Ming-Jiunn et al are disposed below the pad electrode. Therefore, in Ming-Jiunn et al, the current flows from the pad electrode through the second

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conduction-type surface ohmic electrodes below into a light-emitting part of hetero-junction structure and the light is emitted under the pad electrode. Subsequently, the light emitted under the pad electrode is screened by the pad electrode and does not exit. As a result, the luminescent efficiency decreases.

On the other hand, the second conduction-type surface ohmic electrode of the present invention does not exist below the pad electrode. As explained in Applicants' specification at page 13, line 26 to page 14, line 3, when the second-type surface electrodes are not disposed below the pad electrode, the current does not flow into the light-emitting part under the pad electrode, and, therefore, the light that is generated is not wasted.

Ohba et al does not cure the above-described deficiencies of Ming-Jiunn et al. Ohba et al has been relied on for allegedly disclosing a boron phosphide buffer layer. However, Ohba et al simply does not disclose or fairly suggest a second conduction-type surface ohmic electrode composed of a plurality of electrodes which does not exist below the pad electrode.

Further, with respect to independent claim 21, Ohba et al does not disclose a buffer layer of an amorphous body utilized to relax the lattice mismatch. Ohba et al simply discloses an Si-doped p-type BP buffer layer. See, column 11, lines 50-51. By comparison, the BP-based buffer layer of the present invention is composed of an amorphous body in the as-grown state. As explained at page 9, lines 25-28 of the Applicants' specification, the buffer layer is particularly effective in relaxing the lattice mismatch between the electrically conductive single crystal material constituting the substrate and a constituent layer of the stacked layer structure. Thus, clearly the boron phosphide buffer layer of Ohba et al and the present invention are not the same.

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Like Ohba et al, Okazaki et al does not supply the missing features in Ming-Jiunn et al. In particular, Okazaki et al discloses that the insulating block 11 (i.e., a dielectric layer of silicon dioxide) is disposed under the anode 17 (i.e., pad electrode). Insulating block 11 electrically isolates P-type GaN layer 7 from pad electrode 17 and prevents direct current from flowing between p-type GaN layer 7 and the pad electrode 17.

Further, pad electrode 17, is formed in part on a portion of a current spreading layer. See, column 4, lines 42-45 and column 5, lines 22-24. In contrast, the present invention calls for the whole of a pad electrode for wire bonding being in the center of the upper surface of the window layer. Moreover, in the present invention there is no insulating block under the pad electrode, and therefore, the current does not flow into the light-emitting part under the pad electrode. Thus, the luminescent efficiency is not decreased, for the aforementioned reasons. Accordingly, even if combined in the manner suggested by the Examiner the skilled artisan would not arrive at the presently claimed invention. Withdrawal of this rejection is in order and it is respectfully requested.

Claims 4 and 5 stand rejected under § 103(a) as being unpatentable over Ming-Jiunn et al, Ohba et al and Okazaki et al as applied to claim 1 above, and further in view of Bastek (U.S. Patent No. 4,232,440). This rejection is traversed.

Ming-Jiunn et al, Ohba et al and Okazaki et al have been discussed above. Bastek has been applied for allegedly teaching a second conduction-type surface ohmic electrodes 16 disposed at isometric positions from the center of a pad electrode 15 in order to make contact to a light emitting portion of a light emitting device with a high degree of reliability and with minimum interference with light emission. However, Bastek does not cure the above described

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deficiencies in Ming-Jiunn et al. In particular, Bastek does not disclose or fairly suggest that the second conduction-type surface ohmic electrode is composed of a plurality of electrodes and that these electrodes do not exist below the pad electrode. Thus, withdrawal of this rejection is in order and it is respectfully requested.

Claims 11-13, 16, 17, 19, 20 and 22 stand rejected under § 103(a) as allegedly being unpatentable over Ming-Jiunn et al in view of Okazaki et al. This rejection is traversed for the following reasons.

The Examiner has cited Ming-Junn et al and Okazaki et al for virtually the same reasons as stated with respect to the first rejection. Further, the Examiner states that Okazaki, *inter alia*, teaches that the surface ohmic electrodes are disposed in a periphery of the pad electrode; that the surface ohmic electrodes are disposed at a bilaterally symmetric position with respect to the center of the pad electrode; that the surface ohmic electrodes as being disposed in an open light-emitting region other than a projective region of the pad electrode on the surface of the Group-III nitride crystal layer; that the sum of areas of surface ohmic electrodes is from 5 to 30% of a total area of the open light-emitting region.

As discussed above, these claims may not be properly rejected over Ming-Junn et al and Okazaki et al, for at least the same reasons discussed above. In this regard, neither Ming-Junn et al nor Okazaki et al discloses or fairly suggests that the second conduction-type surface ohmic electrode is composed of a plurality of electrodes and that these electrodes do not exist below the pad electrode. Accordingly, withdrawal of this rejection is in order and it is respectfully requested.

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In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,



Iurie A. Schwartz
Registration No. 43,909

SUGHRUE MION, PLLC
2100 Pennsylvania Avenue, N.W.
Washington, D.C. 20037-3213
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

Date: October 25, 2002

APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claim 22 is canceled.

The claims are amended as follows:

1. (Twice Amended) A group-III nitride semiconductor light-emitting diode comprising at least a first conduction-type single crystal substrate provided with a first conduction-type back-surface ohmic electrode on a back surface thereof, a buffer layer comprising a boron phosphide (BP)-based material on a front surface of said single crystal substrate, a gallium nitride (GaN)-based group-III nitride crystal layer having a light-emitting part of hetero-junction structure on said buffer layer, and a window layer comprising an electrically conducting transparent oxide crystal layer on said group-III nitride crystal layer, wherein at least a second conduction-type surface ohmic electrode conductive with said window layer is between the surface of said group-III nitride crystal layer and said window layer and comes into contact with the surface of said group-III nitride crystal layer, the whole of a pad electrode for [wide] wire bonding is on the center of the upper surface of said window layer, and said second conduction-type surface ohmic electrode is composed of a plurality of electrodes and does not exist below said pad electrode.

2. (Amended) The group-III nitride semiconductor light-emitting diode as claimed in claim 1, wherein said second conduction-type surface ohmic [electrode is] electrodes are disposed in a periphery of said pad electrode.

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3. (Amended) The group-III nitride semiconductor light-emitting diode as claimed in claim 1 or 2, wherein said second conduction-type surface ohmic [electrode is] electrodes are disposed at a bilaterally symmetric position with respect to the center of said pad electrode.

5. (Amended) The group-III nitride semiconductor light-emitting diode as claimed in claim 1 or 2, wherein said second conduction-type surface ohmic [electrode is] electrodes are composed of a plurality of electrodes disposed at equal intervals.

6. (Amended) The group-III nitride semiconductor light-emitting diode as claimed in claim 1 or 2, wherein said second conduction-type surface ohmic [electrode is] electrodes are disposed in an open light-emitting region other than a projective region of the pad electrode on the surface of said group-III nitride crystal layer.

11. (Twice Amended) An electrode for group-III nitride semiconductor light-emitting diodes for a group-III nitride semiconductor light-emitting diode comprising at least a gallium nitride (GaN)-based group-III nitride crystal layer having a light-emitting part of a hetero-junction structure, and a window layer comprising an electrically conducting transparent oxide crystal layer provided on said group-III nitride crystal layer, wherein at least a surface ohmic electrode conductive with said window layer is between the surface of said group-III nitride crystal layer and said window layer and comes into contact with the surface of said group-III nitride crystal layer, the whole of a pad electrode for wire bonding is on the center of the upper surface of said window layer, and said surface ohmic electrode is composed of a plurality of electrodes and does not exist below said pad electrodes.

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12. (Amended) The electrode for group-III nitride semiconductor light-emitting diodes as claimed in claim 11, wherein said surface ohmic [electrode is] electrodes are disposed at a position in a periphery of said pad electrode.

13. (Amended) The electrode for group-III nitride semiconductor light-emitting diodes as claimed in claim 11 or 12, wherein said surface ohmic [electrode is] electrodes are disposed at a bilaterally symmetric position with respect to the center of said pad electrode.

15. (Amended) The electrode for group-III nitride semiconductor light-emitting diodes as claimed in claim 11 or 12, wherein said surface ohmic [electrode is] electrodes are composed of a plurality of electrodes disposed at equal intervals.

16. (Amended) The electrode for group-III nitride semiconductor light-emitting diodes as claimed in claim 11 or 12, wherein said surface ohmic [electrode is] electrodes are disposed in an open light-emitting region other than a projective region of the pad electrode on the surface of said group-III nitride crystal layer.

18. (Amended) The electrode for group-III nitride semiconductor light-emitting diodes as claimed in claim 11 or 12, wherein the group-III nitride crystal layer in contact with said surface ohmic [electrode] electrodes comprises gallium phosphide nitride represented by $\text{GaN}_{1-x}\text{P}_x$ wherein $0 < x < 1$.

19. (Twice Amended) A method for producing an electrode for group-III nitride semiconductor light-emitting diodes, comprising

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forming a plurality of surface ohmic electrodes in contact with a surface of a gallium nitride (GaN)-based group-III nitride crystal layer having a light-emitting part of hetero-junction structure,

then covering the surface of said group-III nitride crystal layer and said surface ohmic electrodes to form a window layer comprising an electrically conducting transparent oxide crystal layer conductive with said surface ohmic electrodes, and

then forming a whole of a pad electrode for wire bonding on a center of the upper surface of said window layer conductive with said window layer, wherein said surface ohmic electrodes do not exist below said pad electrode.

21. (Twice Amended) A group-III nitride semiconductor light-emitting diode comprising at least a first conduction-type single crystal substrate provided with a first conduction-type back-surface ohmic electrode on a back surface thereof, a buffer layer comprising a boron phosphide (BP)-based material on a front surface of said single crystal substrate, a gallium nitride (GaN)-based group-III nitride crystal layer having a light-emitting part of hetero-junction structure on said buffer layer, and a window layer comprising an electrically conducting transparent oxide crystal layer on said group-III nitride crystal layer, wherein at least a second conduction-type surface ohmic electrode conductive with said window layer is between the surface of said group-III nitride crystal layer and said window layer [and comes into contact with the surface of said group-III nitride crystal layer and] is disposed in an open light-emitting region other than a projective region of a pad electrode on the surface of said group-III nitride crystal layer, [the] a pad electrode for wire bonding is on the center of the upper surface of said window

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layer, and wherein a sum of areas of said second conduction-type surface ohmic electrodes is from 5 to 30% of a total area of said open light-emitting region and said buffer layer is composed of an amorphous body in the as-grown state.